# Evanescent Acoustic Wave Scattering by Targets and Diffraction by Ripples

PI name: Philip L. Marston
Physics Department, Washington State University, Pullman, WA 99164-2814
Phone: (509) 335-5343    Fax: (509) 335-7816    Email: marston@wsu.edu

Co-PI: Curtis F. Osterhoudt
Physics Department, Washington State University, Pullman, WA 99164-2814
Phone: (509) 335-4946    Fax: (509) 335-7816    Email: gardyloo@mail.wsu.edu

**LONG-TERM GOALS**

The goal is to develop and test certain ideas relevant to the coupling of sound with small targets buried in the ocean bottom.  This is a "Graduate Traineeship Award" in Ocean Acoustics.

**OBJECTIVES**

The main objective is to understand consequences of incident wave evanescence on (existing or under-utilized) scattering observables.  It is also planned to explore conditions whereby surface roughness enhances the coupling of sound to simulated buried targets.  Resolving these issues should be helpful for discriminating between echoes from real buried targets and background objects.

**APPROACH**

Simulation experiments will be carried out and the results will be compared with theoretical predictions.  Professor Philip L. Marston directs the research (while receiving no financial support from this grant).  Curtis F. Osterhoudt is a graduate student supported by this grant at Washington State University.

**WORK COMPLETED**

We previously identified an environmentally-friendly liquid mixture that, when placed in contact with water, has the desirable acoustic contrast to facilitate the production of acoustic evanescent waves in a liquid having a substantial volume.  The mixture does not mix with water and is denser than water and typically has a speed of sound of 885 m/s. The emphasis in FY-2005 has been to conduct experiments with a system containing approximately 70 gallons of the dense liquid surrounded by a 3000 gallon water tank.  This system was used to generate wavefields having significant evanescent components by illuminating the interface with a beam having post-critical incidence. The source transducer is placed in the dense liquid mixture, which simulates the ocean water column.  The water in the tank above the mixture simulates the ocean bottom.  Hydrophones to detect and measure scattering may be placed either in the water (the simulated bottom) or in the mixture (the simulated water column).  There has been progress in measuring and modeling the incident evanescent wavefield as well as in measuring the scattering by small targets in this wavefield [1,2].

# Report Documentation Page

| 1. REPORT DATE<br>**30 SEP 2005** | 2. REPORT TYPE | 3. DATES COVERED<br>**00-00-2005 to 00-00-2005** |
|---|---|---|
| 4. TITLE AND SUBTITLE<br>**Evanescent Acoustic Wave Scattering by Targets and Diffraction by Ripples** | | 5a. CONTRACT NUMBER |
| | | 5b. GRANT NUMBER |
| | | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | | 5d. PROJECT NUMBER |
| | | 5e. TASK NUMBER |
| | | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**Washington State University,Physics Department,Pullman,WA,99164** | | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

| 12. DISTRIBUTION/AVAILABILITY STATEMENT |
|---|
| **Approved for public release; distribution unlimited** |

| 13. SUPPLEMENTARY NOTES |
|---|
| **code 1 only** |

| 14. ABSTRACT |
|---|
| **The goal is to develop and test certain ideas relevant to the coupling of sound with small targets buried in the ocean bottom. This is a ?Graduate Traineeship Award? in Ocean Acoustics.** |

| 15. SUBJECT TERMS |
|---|

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT<br>**unclassified** | b. ABSTRACT<br>**unclassified** | c. THIS PAGE<br>**unclassified** | **Same as Report (SAR)** | **4** | |

**RESULTS**

Scattering experiments are summarized in the report for grant N000140310585 which supports the principal experimental costs. See the remark under Related Projects. An important part of understanding the scattering is to measure and model the incident wavefield within the simulated bottom (the water tank in this experiment). That aspect of Osterhoudt's research is emphasized in this report. The evanescent wavefield decays upward in the water since the simulated water column (the oil) is denser than (and is trapped below) the simulated water column (the water). This is a convenient arrangement since it allows hydrophones and target positions to be easily scanned within the simulated bottom. Scans of the wavefield in the simulated bottom reveal the fine structure and interference features of the total incident wave [2]. This wavefield, as illustrated in Figure 1, can exhibit complicated nulls associated with the interference of algebraic and exponentially decaying wavefields [3]. Such nulls are predicted by us in wavenumber integration (OASES-based) simulations. We have made recent progress in predicting the spacing of the nulls [2] by extending the approach of Matula and Marston [3].

These observations were with a flat interface. Additional experiments will be carried out to investigate scattering processes. Osterhoudt has also demonstrated an electrical method for exciting ripples on the interface between the two liquids.

**IMPACT/APPLICATIONS**

This research should eventually improve the understanding of the acoustic signatures of buried targets and the acoustic discrimination of target and background acoustic scattering. These experiments suggest that in regions where the sediment is smooth it may still be possible to detect certain targets at grazing incidences by relying on the coupling of evanescent waves with low-frequency, high-Q modes of targets.

**RELATED PROJECTS**

This Graduate Traineeship Award does not cover the significant materials and supplies costs for an experiment of this type. Those costs are covered in part by the following grant from ONR code 32CM: N000140310585, "Scattering of Evanescent Acoustic Waves by Regular and Irregular Objects." Grant N000140310585 has provided partial support for other students and staff who have assisted with this project. Additional information is provided in the report for that grant. Associate Professor Scot F. Morse (Computer Science Department, Western Oregon University) assisted in aspects of the OASES based simulations with the partial support of ONR SWAMSI grant N000140410075.

**REFERENCES**

[1] C. F. Osterhoudt, C. Dudley, D. B. Thiessen, P. L. Marston, and S. F. Morse, "Production of evanescent acoustic waves and their scattering by resonant targets," J. Acoust. Soc. Am. 117, 2483 (A) (2005).

[2] C. F. Osterhoudt, P. L. Marston, and S. F. Morse, "Wave field and evanescent waves produced by a sound beam incident on a simulated sediment," J. Acoust. Soc. Am. 118, 1970 (A) (2005).

[3] T. J. Matula and P. L. Marston, "Energy branching of a subsonic flexural wave on a plate at an air-water interface. I: Observation of the wave field near the interface and near the plate," J. Acoust. Soc. Am. 97, 1389-1398 (1995).
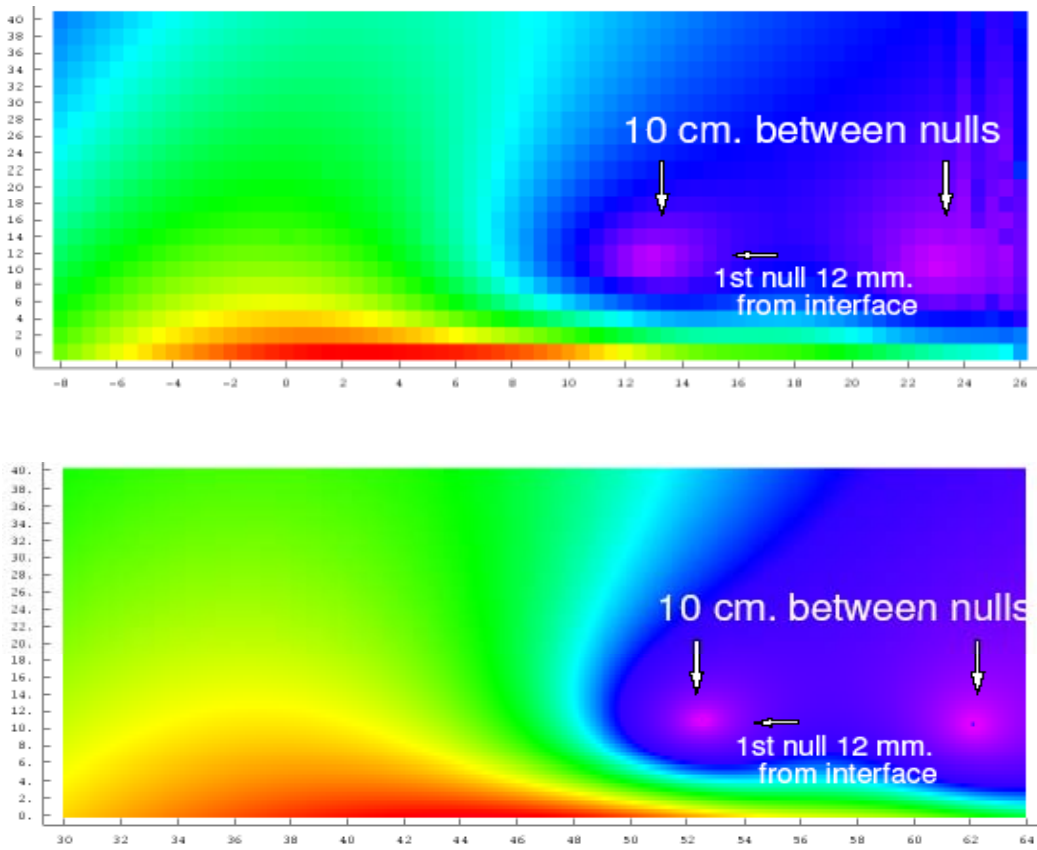
*Figure 1. Measured 60 kHz wavefield (upper) and wavenumber-integration based simulation (lower) in the simulated sediment (the water) have similar features. The oil-water interface is below the region show and the sound beam is incident in the oil from the left. The evanescent wave propagates to the right. The vertical axis in each section of the figure is proportional to the distance into the simulated sediment from the interface. The null features visible in the measured and simulated wavefields are a consequence of the interference with the evanescent wave from diffractive components caused by the finite size of the source.*